Earthshine as an Illumination Source in Permanently Shadowed Regions

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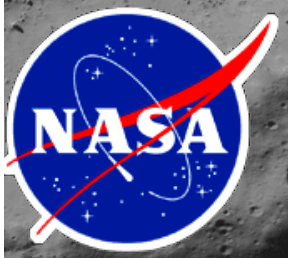
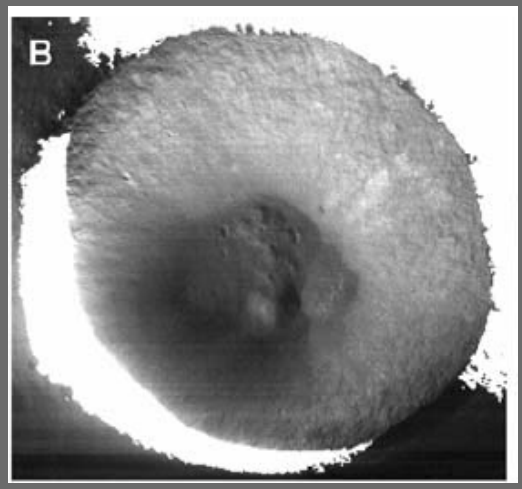


UMBC

PSR Searches using Scattered Light

- Haruyama et al. (2008) imaged Shackleton Crater using SELENE Terrain Camera. Light source was solar illuminated crater rim. Surface albedo too low for abundant, unmixed, surface ice.



- Paige et al. (2010) compared Diviner results with illumination model including direct and scattered sunlight, and direct Earthshine. Simulation used simple (circa ’69) Earth radiation budget model.

- Mazarico et al. (2011) estimated scattered sunlight at selected points. Surface irradiance up to ~7,000 mW m^{-2}. Annual averages to 1,500 mW m^{-2}. Study included Earth visibility but no estimates of Earth energy input.

This Study . . .

We examine Earthlight as a secondary illumination source in PSR's.

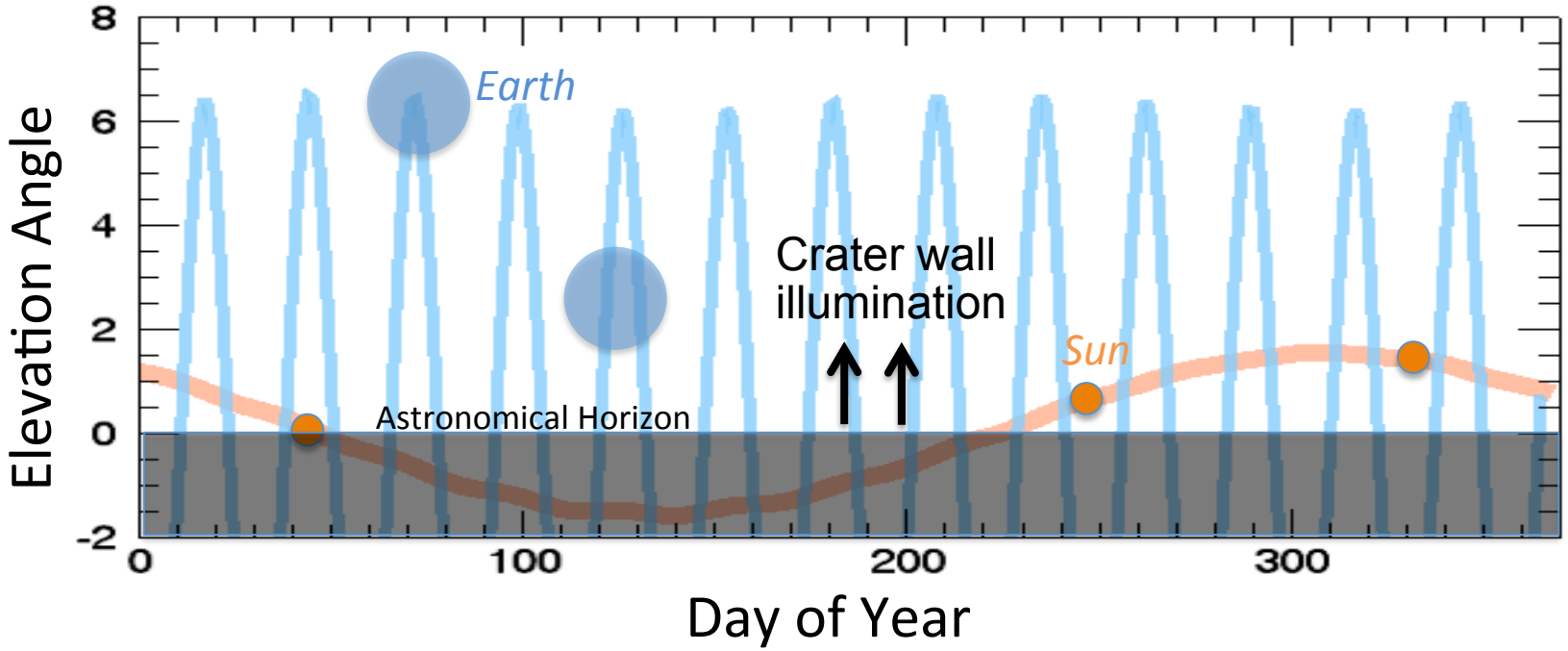
Questions Addressed:

- Can Earthlight provide sufficient radiance to influence the stability of volatiles in PSR's?
- In absence of sunlight, Is it bright enough for future robotic optical sensing (imaging, photometry, spectroscopy, polarimetry) in these areas?

Approach:

- Use "idealized" Shackleton Crater geometry, located at South Pole. Azimuthally symmetric profile (no DEM needed).
- Utilize Virtual Planetary Laboratory/ VPL (NASA, U. Wash.), Earth radiance models. Constrained by EPOXI Earth observations.
- Compute direct and scattered illumination at the crater, at solar-band and thermal wavelengths.

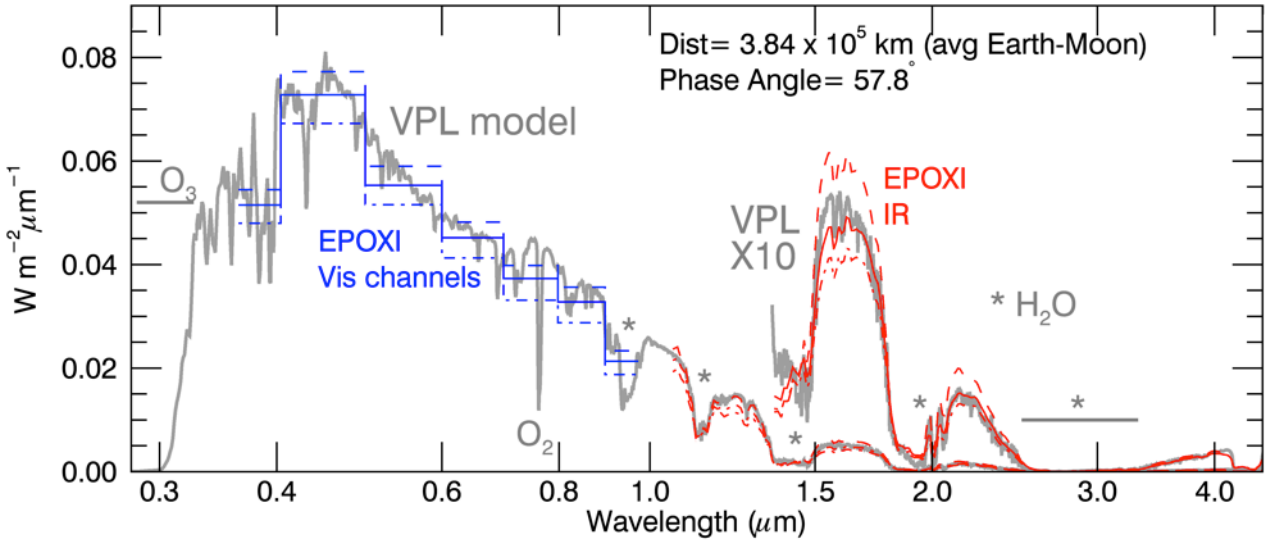
Illumination at Shackleton Crater



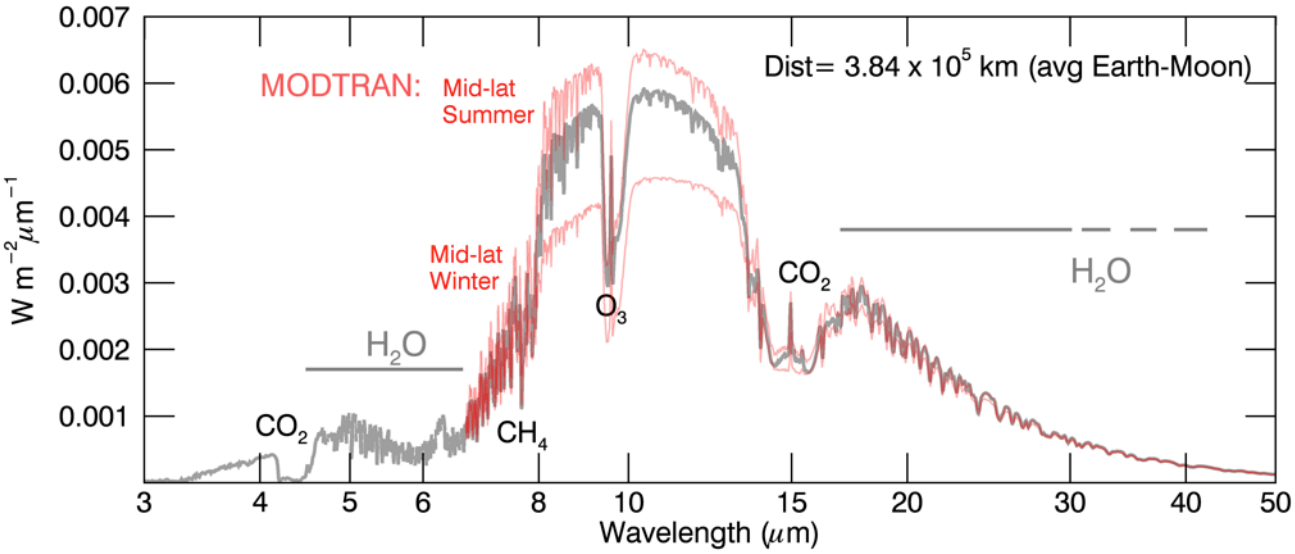
- Top portion of crater wall receives direct solar light in Summer only. Larger areas of the wall receive direct Earthlight all year long.
- Earth at solar band goes through phases. “Thermal” Earth is constant full-phase.

Earth Irradiance at the Moon - Spectral

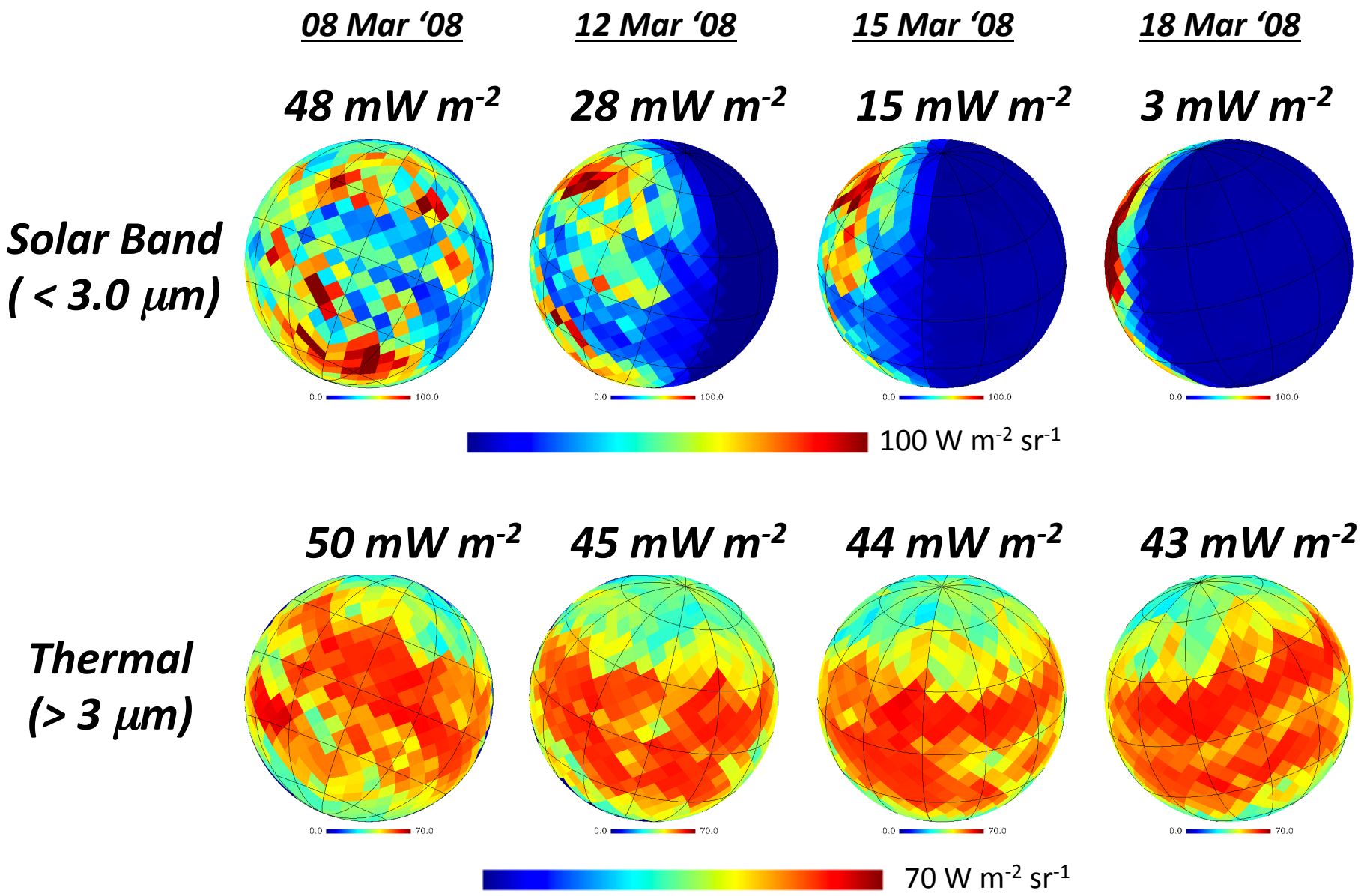
Solar Band



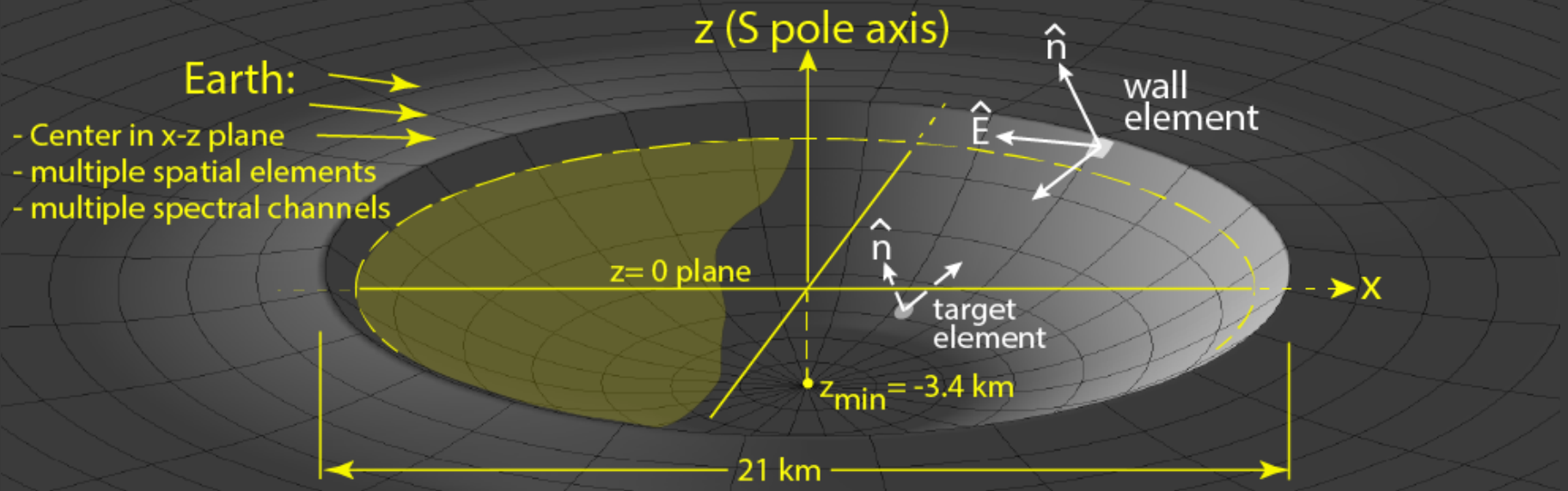
Thermal



Earth Irradiance at the Moon - Maps



Model Geometry – Shackleton Crater



Radiometric Model:

- Radiance from unocculted Earth elements is summed at each wall element. Separate "bookkeeping" for solar band and thermal wavelengths.
- Each illuminated wall element scatters onto all target elements. Use Hapke reflectance function at solar band. At thermal, assume e~0.9 (r~ 0.1).
- Summations give the scattered light irradiance at the crater floor.

Crater Illumination – Sample Results

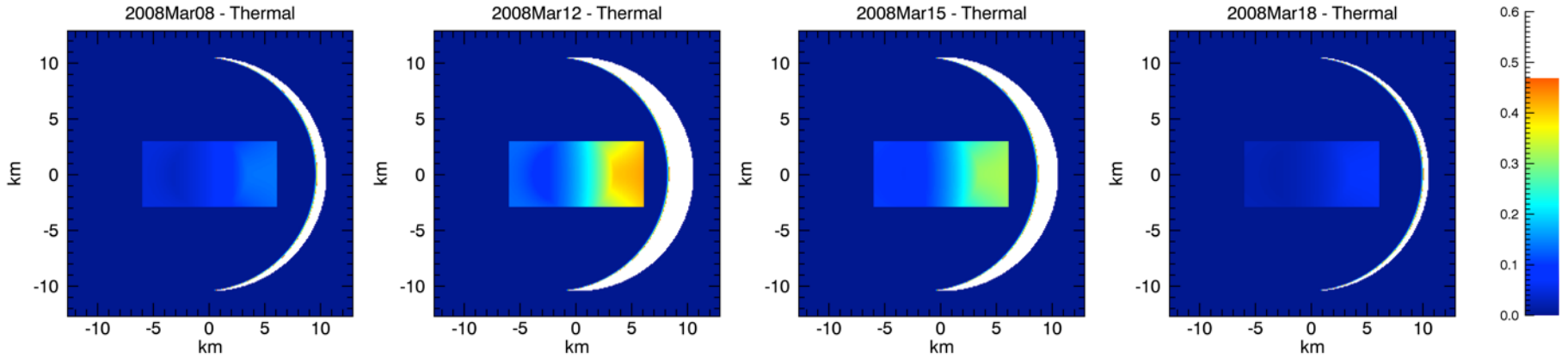
Mar 8
Elev 2.5°
Earth Illum 100 %

Mar 12
Elev 6.4°
Earth Illum 77 %

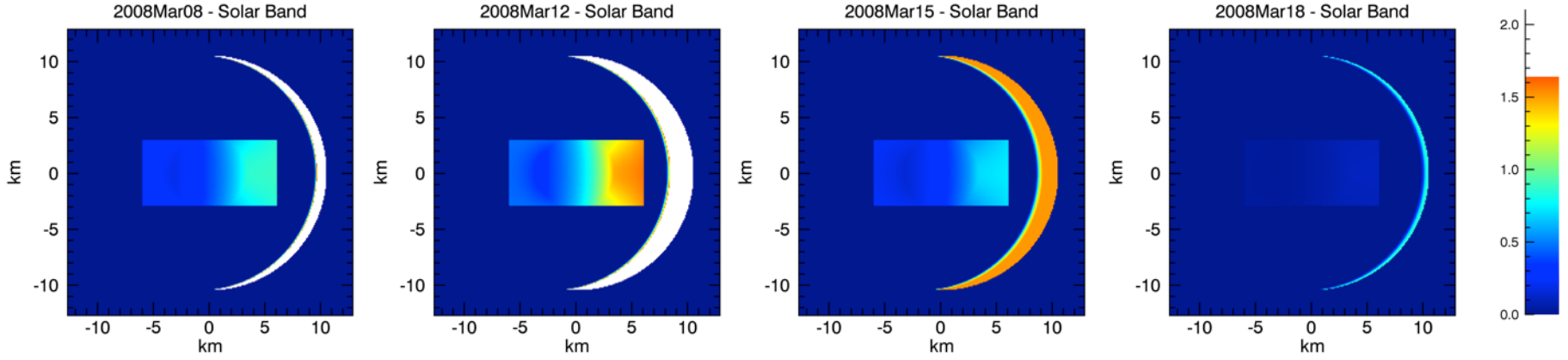
Mar 15
Elev 5.3°
Earth Illum 44 %

Mar 18
Elev 1.4°
Earth Illum 15 %

Thermal



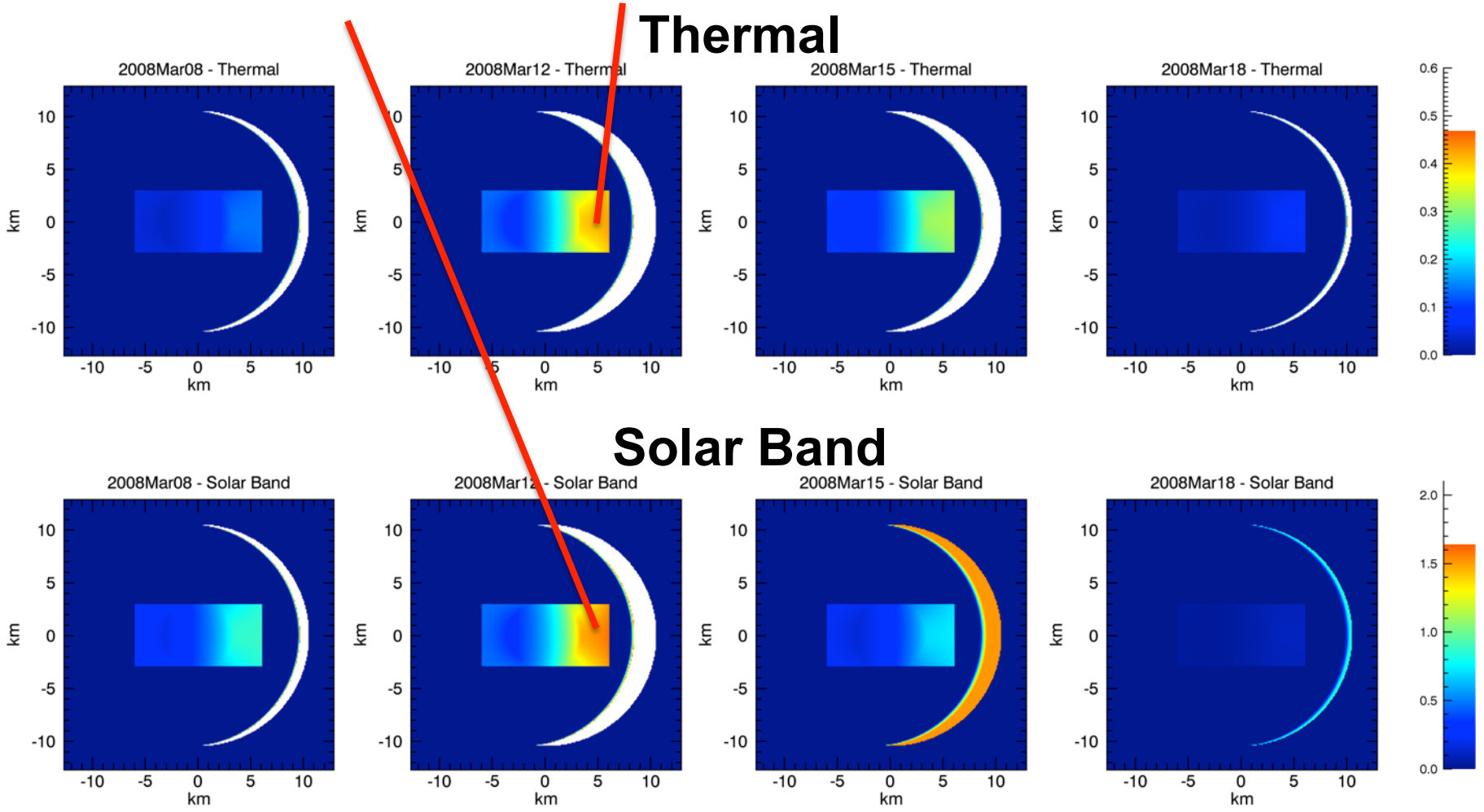
Solar Band



Crater Illumination – Sample Results

Solar band:
~ 1.5 mW m^{-2}

Thermal:
~ 0.4 mW m^{-2}



Summary and Status

- Surface irradiance of Earth scattered light within Shackleton crater gets as large as ~1.5 mW m^{-2} (solar band), and ~0.5 mW m^{-2} (thermal), depending on Earth phase and elevation angle.
- These values are within an order-of-magnitude of present estimates for internal heat flow in PSR's (10-20 mW m^{-2}).

Current tasks:

- Estimate the interior surface brightness under these illumination conditions. Can crater interior be measured with high signal-to-noise,using Earthlight alone?
- Add VPL results at 1-day cadence, spanning a full lunation, in order to get the time-average energy input.
- *This is very much a work in progress.* ☺